The Preparation and Use of Artificial Diets for Rearing Insects

By Brian O. C. Gardiner*

Introduction

It has been known for a long time that alternative foodplants to those chosen in nature have been used for feeding larvae where their normal food is not available. Usually these alternatives are plants related to the foodplant normally chosen. Just why an insect, which is capable of utilising a variety of plants as food should specifically select one sort in preference to another is a mystery, but there are no doubt several explanations. There may be less competition from other species; a differential rate of growth may provide more favourable conditions at a given time of year; the spread — often by human agency — of a species may introduce it to plants not previously accessible but which happen to be ideal pabula.

The breeder can, however, utilise the fact that other foods are acceptable to rear very many species away from their normal location and where their foodplant does not occur. This applies particularly to tropical species and it is often a fact that many of these are easier to rear in a temperate region than they are in their place of origin. The explanation may well be that they have been removed from sources of their normal disease organisms which would otherwise be introduced with the food and cause a high mortality.

Nevertheless, even alternative foods may present certain difficulties. In England, for instance, imported Japanese Lycaenidae have a habit of hatching before the leafbuds have developed enough to be suitable as food. Evergreen oak (*Quercus ilex*), in winter, is sere and hard, producing undersized silkmoths. Fresh spring Privet (*Ligustrum ovalifolium*) gives Eri silkmoths diarrhoea. Finally, all foodplants, natural or alternative, have to be collected, usually daily and often from a considerable distance, and they also have to be kept fresh — no easy task with some plants such as Poplar (*Populus* sp.). For the town flat dweller in particular, the collection of foodplants, for which he may well have to rely on the benevolence of friends with gardens, can present problems. So can the housing of his larvae.

Tropical fish, cats, dogs and canaries can all be fed from a packet obtainable from the nearest grocer. It is now possible to rear caterpillars and other insects on exactly the same basis.

There are, of course, a few insects that have always been known to feed on "artificial" food. These belong to the so-called "Pest" species and include the well-known Clothes moths, Flour moths, Wax moths, Carpet beetles, Tyroglyphid mites, etc. The ever-increasing demand for more and better (sic?) insecticides, led in turn to the demand for ever-increasing quantities of larvae to be available 365 days a year so that continuous research could be kept up. The possibilities of

* A.R.C. Unit of Invertebrate Chemistry and Physiology, Department of Zoology, Downing Street, Cambridge.

silk production also led to the search for ways of feeding larvae on some form of artificial diet. These two industries between them have poured large sums of money into investigating the problem and after many years results were obtained. The problem has now passed its infancy, and several hundred species of Lepidoptera, as well as those of other orders, have been reared, some for many generations, entirely on artificial foods.

There are several of these. Basically they are a jelly which is poured, warm, into a suitable container and allowed to set. They may or may not contain a percentage of the natural food, which acts as an initial feeding stimulant. It is initial feeding which is one of the problems. If natural food be not added (in the form of dried powered leaf) it may be necessary to add an alternative feeding stimulant, which in the case of cabbage feeders, is the mustard oil glucoside "sinigrin" available from a chemical firm.

Not unnaturally, perhaps, species normally polyphytophagous appear to date to be in the majority reared by this method. Also, somewhat surprisingly, a cabbage-flavoured medium has proved acceptable and suitable to a Privet feeder (Eri silkmoth); Nettle feeder (Scarlet tiger), and at least initially acceptable for several instars (ultimate death having been due to disease) to such unlikely species (whose natural foodplants are unknown but are certainly various tropical trees) as *Automeris pyrrhomelas* and *Copaxa multifenestrata.* Locusts, Stick insects, Blow flies and Fruit flies will also accept this same pabulum.

Quite clearly the use of medium for rearing larvae requires much further investigation. It is a subject in which the amateur, who is prepared to take a little trouble in the fairly accurate initial making-up of the medium, and who is willing to risk losses, can play a considerable part.

The advantages of using a medium are: — That one is independent of the seasons and the often daily collection of foodplant in all weathers; the medium is sterile and unwanted organisms are not accidentally supplied to the larvae; jars of medium take up less room than cages; larvae require attention about once a week instead of daily, although large larvae need to be cleaned out more often. This last factor brings the rearing of larvae within the range of many who for business reasons, may have to be absent from home for regular periods. It is also ideal for cannabilistic larvae (Dunbar moth) which must be reared in isolation and hence represent an awful lot of work. These can be set up individually in small glass tubes.

Once the required apparatus and ingredients are assembled, the making of the media presents little trouble. The main disadvantage is primarily the initial expense, although even this need not be great and will depend to a large extent on what facilities the breeder already has to hand, and also how much he is prepared and able to improvise. In

any case, this expense is certainly no more than that of a well equipped tropical fish tank or small aviary. Furthermore, it may be balanced to some extent against the saving in conventional larvae cages.

There are a number of diets in existence and there is a fair amount of variation between them. Some have been developed for a particular insect and then further refined. Others have been used for a number of species. Some rather different mediums are described below. But first a few words about their preparation.

Ingredients

These may nearly all be bought through usual trade sources, such as laboratory supply houses and chemists, althogh some of them may have to be specially ordered. Ready dried leaf powders of alfalfa, grass, cabbage and nettle are also available, though no one supplier appears to stock all of them. A prepared medium is available from one well known laboratory supply house.

The dried leaf powder when used will depend on the species being reared. For Pierids, Arctiids and many Noctuids, it does not appear to be necessary. However, in order to prepare dry leaf powder not commercially available, the freshest possible leaves of the natural foodplant should be gathered and all the coarser stalk removed. The leaves should then be placed in single layers on wire cake trays and dried for at least half an hour at about 120°C., using any suitable oven. They can then be ground to a fine powder using a blender, but there needs to be more than enough of the dried leaf when powdered, to entirely cover the blades.

Wesson salts, which is a mixture of essential minerals, requires to be as finely powdered as possible. It is on the market in America but does not appear to be readily obtainable in U.K., the only source known to me being Messrs. Kodak Ltd. Its constituents, however, are all available and for those who have difficulty, or would prefer to mix up their own, these are given in Table I.

TABLE I

The constituents, by proportion, of Wessons salts as used for the artificial diets.

$CaCO_3$ (Calcium carbonate)	120
K_2HPO_4 (di-Sodium hydrogen orthophosphate)	129
$CaHPO_4$ (Calcium hydrogen phosphate)	30
$MgSO_4$ (Magnesium sulphate)	40.8
NaCl (Sodium chloride)	67
FeC_6H_2O (Ferric citrate)	11
Kl (Potassium iodide)	0.32
$MnSO_4$ (Manganese sulphate)	2
$ZnCl_2$ (Zinc chloride)	0.1
$CuSO_4$ (Copper sulphate)	0.12

The vitamin solution generally used in the various diets is perhaps best prepared by a chemist. The ingredients are expensive and an extremely accurate balance is necessary. Once obtained however, in the minimum available quantities, there will be enough for hundreds of batches of media and many thousands of larvae. When made up, the vitamin solution must be stored in a refrigerator. It is very possible that the medical preparation "Lederplex" (manufactured by Cyanimid of Great Britain Ltd.) would prove a suitable alternative. It lacks, however, Folic acid and D-biotin which it would be essential to add separately. It also contains Choline and Inositol, which are known to be advantageous to larval growth. The composition of the vitamin solution is shown in Table II.

The made up vitamin solution should be kept refrigerated. It can be made up using water only, but in that case there is a serious risk of bacterial decomposition which is normally prevented by the alcohol. The following solutions will also be required and once made up should all be kept under refrigeration.

Choline chloride: This is used as a 10% aqueous solution.

Methyl parahydroxy-benzoate: This is added in the form of a 15% solution in Ethyl alcohol also used with the vitamins, a substance which is very expensive indeed. Since the rearing of larvae is a legitimate scientific pursuit, application should be made to H.M. Customs and Excise for a permit to buy duty-free alcohol. It is also possible that the ready-made solution may be bought free of duty. Enquiries should be made beforehand.

Formaldehyde: This is used at a strength of 10%.

Agar: This should be added to cold water and heated in a double saucepan or suitable waterbath, otherwise it will burn. The use of Gelatine and Sodium alginate in place of agar requires investigation.

TABLE II

The composition of the vitamin additive for the artificial diets.

Ethyl alcohol	50 ml.
Water	50 ml.
Nicotinic acid	600 mg.
Calcium pantothenate	600 mg.
Riboflavine	300 mg.
Aneurine hydrochloride	150 mg.
Pyridoxine hydrochloride	150 mg.
Folic acid	150 mg.
D-biotin	12 mg.
Cyanocobalamine	1.2 mg.

(*To be continued*)